

10. FLIGHT OPERATIONS TRAINING & CERTIFICATION

Training will be accomplished in a number of areas so the FOT can acquire the spacecraft knowledge and expertise necessary to effectively conduct TRMM mission operations. Such areas will include all spacecraft and instrument subsystems, MOC systems, ground element interfaces, and operational scenarios for real-time and off-line activities. Figure 10-1 illustrates the timeline planned for FOT training and certification, and the following sections describe the detailed training and certification approach for the team.

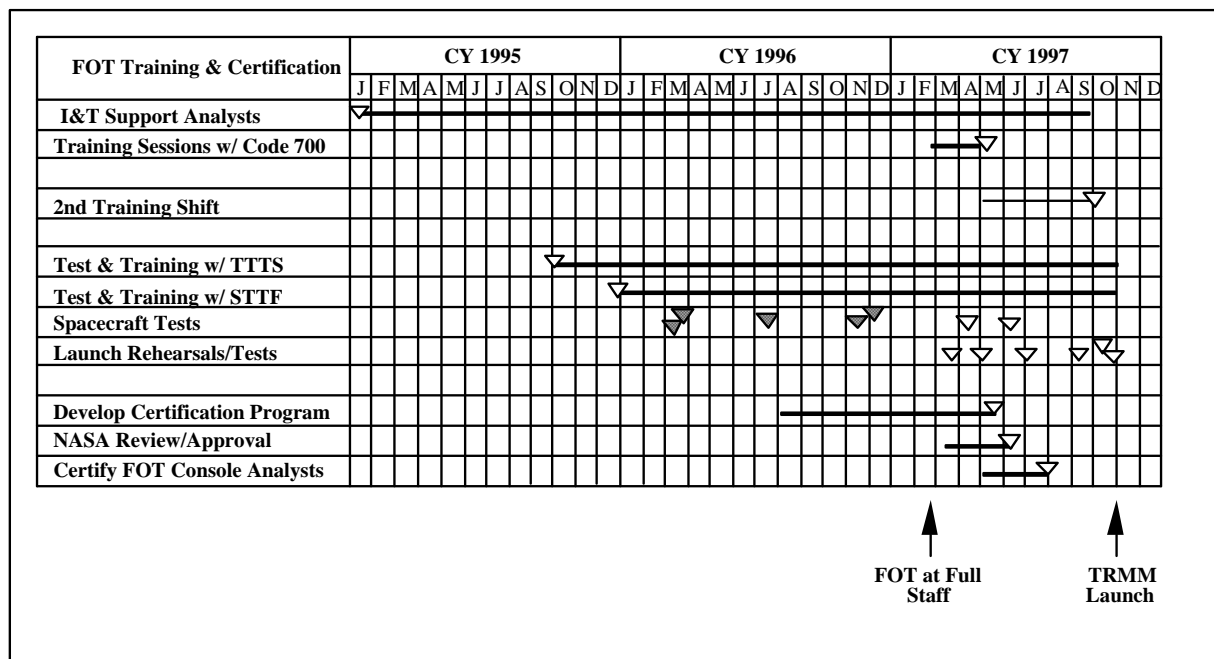


Figure 10-1 FOT Training and Certification Timeline

10.1 SPACECRAFT SUBSYSTEM & INSTRUMENT TRAINING

Spacecraft subsystem training will be administered by the senior members of the FOT, with support from the GSFC Engineering Directorate, NASA Code 700. Such training will be in three forms, subsystem design documentation, hands-on training with the spacecraft, and classroom style training.

10.1.1 Spacecraft Subsystem and Instrument Documentation

Spacecraft subsystem and instrument training includes study, by the FOT, of existing documentation which describes the technical design and operational aspects of each subsystem and instrument. This includes Critical Design Review (CDR) packages reflecting subsystem hardware and software and detailed User's Guides for the FDS and ACE. This documentation, developed by Code 700 and instrument developers, will provide the basis for the FOT's understanding of the TRMM spacecraft and instruments, and their operational requirements. In

addition, this Flight Operations Plan (FOP) will provide a current and consolidated source of information describing not only the operations needs of each spacecraft subsystem and instrument, but also how the TRMM ground systems will be operated to support mission operations. The FOT intends to utilize the FOP as an introductory training tool for all new FOT analysts and engineers.

10.1.2 Spacecraft Hands-on Training

Hands-on training will be provided through actual telemetry and command interaction with TRMM, while the observatory is at GSFC Building 7/10. The TRMM Project has allotted seven opportunities when S/C testing with the ground system and FOT training can occur. Details on test and training objectives along with scheduled opportunity dates are documented in the TRMM Observatory to MOC Interface Test Plan (July 1994). It is expected that all supporting ground system elements will also take advantage of these opportunities and participate to the best of their capabilities.

In addition, hands-on training will be supported by the Spacecraft Test and Training Facility (STTF) by allowing FOT access to the spacecraft simulator. This simulator is comprised of a number of Engineering Test Units (ETUs) hosting actual flight software. Interface testing with the STTF will provide a high fidelity simulation capability for attitude and orbit maneuvers, and table and memory load/dump operations.

10.1.3 Classroom Style Training

Classroom style training will be conducted in conjunction with the TRMM developer, namely NASA Code 700, and its supporting contractors. Specific training dates, training material, and facilities for such training will be coordinated by the FOT. The approach is to prepare comprehensive training material for each subsystem which describes all operational aspects related to normal operations and contingencies. This material may be in the form of existing documentation and will not necessarily require additional effort. Several individual training sessions will be arranged with each subsystem engineer, or in some cases multiple subsystem engineers. Each session will generally consist of senior FOT personnel and Code 700 engineers guiding a discussion on the subsystem followed by an informal question and answer period. Two separate training time-frames have been identified for this purpose.

10.2 MOC SYSTEMS TRAINING

MOC facility familiarization and training will be an important activity as the FOT begins its effort to understand and use the software and hardware systems that comprise the MOC. This training will include all facets of the MOC including real-time operations, off-line activity, use of support tools such as the data base management tool (Oracle), and various specialized systems such as the OBC Support Tools (OST) Workstation, SpaceViews, and the Generic Trend Analysis System (GTAS). Interface activities with other support elements external to the MOC will also be exercised.

MOC systems training is expected to begin in earnest with the Release-1 software delivery of the TRMM MOC system (installed in SOTA Bay 4 in February 1995, and then in the TRMM MOC in July 1995). Driving this is the first interface with the spacecraft during December 1995. Once the dedicated TRMM Mission Operations Room (MOR) is available, all MOC system training

will be from this area. The MOR is scheduled to be ready for FOT occupancy in June 1995. Initial MOC system training will be supported by the MOC development staff. This training is expected to be brief and high-level (one or two days maximum). More in-depth FOT training will be accomplished by reference of the MOC Systems User's Guide and actual hands-on use of the systems.

In addition, it is safe to say that facility training will occur concurrent with all degrees of testing from internal MOC checkout through actual spacecraft testing. An important consideration is early FOT participation in the MOC system and acceptance test periods. The FOT can get an advanced look into new system releases as they work with both the software developers and the combined test team (CNMOS teams) prior to software releases, and during the acceptance testing periods. In this way, the FOT can advise on possible enhancements, determine discrepancies, and provide a user perspective as to required corrective action. This is to be an ongoing process across all MOC system releases with FOT participation several weeks prior.

Also, specialized training related to FOT development efforts will begin prior to June 1995. These areas would mainly concern use of the PDB management tool (Oracle), telemetry display generation tools, and MOC Systems Test and Operations Language (STOL) procedure development. An additional peripheral area would be the generation of configuration codes and NCC ground control message procedures needed for operations with the Space Network (SN). Although these require a special data base and additional spacecraft and SN interface information, development activity would provide a timely learning process in these areas during pre-launch testing and afterwards.

10.3 TRAINING SIMULATORS

Two major simulator systems are available for FOT training purposes. These are the TRMM Test and Training Simulator (TTTS) and the spacecraft simulator provided by the STTF. Each simulator is described in more detail in the following sections.

10.3.1 TRMM Test And Training Simulator (TTTS)

The TTTS, operated from Building-25, provides standalone system interface and test opportunities for the FOT. An initial telemetry and command capability will be available in October 1995 prior to the first spacecraft data flow in December. The TTTS serves as a medium fidelity simulator with increasing functionality as software releases become available. Advanced TTTS capabilities include system and orbit based parameter modeling, OBC memory load/dump capability, data interleaving, and simulated failure modes.

Besides telemetry and command activity the FOT expects to use the TTTS for GCMR/ODM checkout as well as in a direct TDRSS interface using the Radio Frequency Simulation Operations Center (RFSOC).

10.3.2 STTF Spacecraft Simulator

The other major simulation system is provided by the STTF located in Building-1. In addition to its primary role of verifying flight software, the STTF spacecraft simulator will provide a high fidelity simulation capability for FOT training. This will include various subsystem and critical operations scenarios such as ACS orbit and attitude maneuvers, SafeHold, and software anomalies.

10.4 FLIGHT TEAM CERTIFICATION

The TRMM Flight Operations Team will require certification prior to conducting on-orbit mission operations. This certification will be in compliance with the Combined Network and Mission Operations Support (CNMOS) contract Certification Program. The purpose of the certification program is to ensure that acceptable levels of proficiency are achieved by all personnel performing direct real-time operations in support of space flight missions. FOT staff, unless directly supervised, will perform only those duties for which they have been certified.

Certification is the verification, through performance and/or written evaluation, that an individual meets the minimum level of proficiency necessary to perform the duties associated with the job position. Three FOT staff positions will require certification, the Real-time Console Analyst, Real-time Command Controller, and the Operations Engineer. Figure 10.4-1 depicts the process by which certification will be achieved.

The certification process utilizes a Skills Checklist that contains the measurable descriptions of all the tasks, skills, and knowledge involved in performing the duties of a particular position. This checklist will be developed by the FOT and reviewed and approved by the Ground System Project Manager. Also, so as to ensure it remains current, a bi-annual review of the skills checklists will be conducted. Once the required performance is verified, final certification is accomplished by successful completion of a written test with a passing grade of 90 % or better. As with the skills checklist, a bi-annual review of the certification test will be conducted to ensure currency.

10.5 GROUND SYSTEM TESTING

The following is a list of various ground system testing to be conducted:

- a. Project I&T spacecraft tests
- b. TTTS testing
- c. Element interface testing
- d. STTF testing
- e. Mission Readiness (MRT) Testing
- f. Launch Site testing

While there is no particular hierarchy, testing with the spacecraft will always take precedence. The FOT will assign their personnel to support all major test efforts. If additional shifts or weekend work is necessary, appropriate staffing will be designated. The FOT expects to go to a two shift arrangement, approximately three months prior to TRMM launch (April 1997). Focus of the second shift will be FOT training, stress testing of the MOC systems, and the conduction of numerous mission simulation exercises.

The TTTS simulator will be the first interface test of any type in which the FOT will participate. The FOT will use the TTTS to check out basic telemetry decommutation and command

functions. Data base input will be provided to TTTS as the FOT receives this input from the Project Software Systems Manager.

Testing with the TTTS will increase in complexity as its software matures. All testing is run with the simulator in the standalone capability from Building 25. When SN End-to-End (ETE) interface testing (employing the RFSOC for its TDRS interface function) is conducted, it will utilize the TTTS in this configuration. SN ETE testing is scheduled to commence in the October 1995 time-frame.

A variety of element interface testing is also to be performed. These could involve the MOC (FOT) to that element exclusively, as a means of verifying that interface, or in total during spacecraft ETE testing when the entire ground support system is worked. Such testing may include non-real time activity such as file and data set transfers, load generation, etc. Operational scenarios involving the SN and DSN/GN networks will also be tested here. Participating elements include FDF, SDPF, NCC, TSDIS, LaRC, MSFC, and the NASDA EOC.

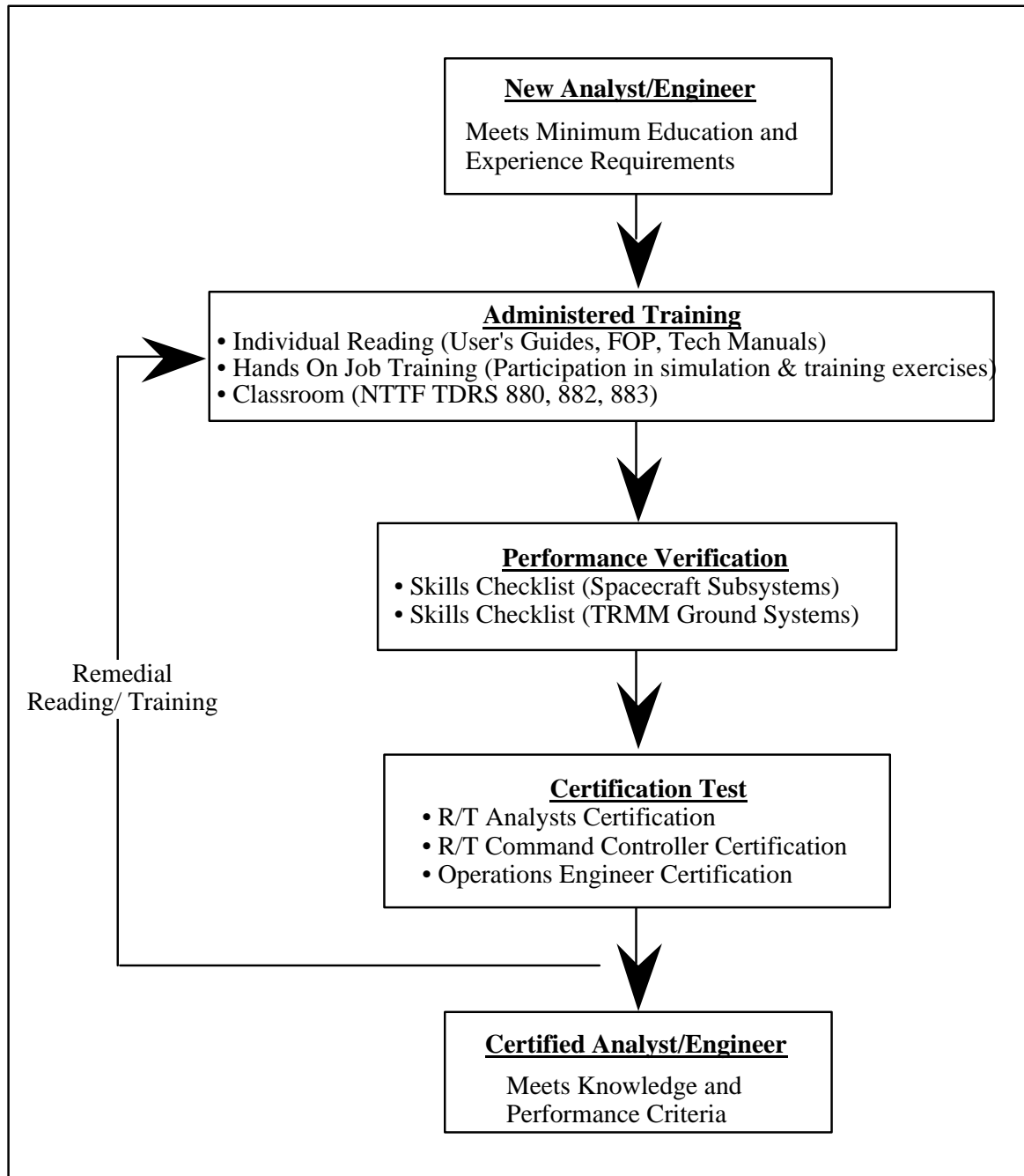


Figure 10.4-1 FOT Certification Process

STTF testing is also expected to be utilized quite extensively. The STTF provides a high fidelity simulations system which the FOT can share. ACS subsystem functions, orbit and attitude maneuvers, processor functions, and operational scenarios may be monitored. A data and voice link to the MOC allows this activity to be conducted. STTF testing is expected on this shared basis, beginning in October 1995. Availability could revolve around off-peak hours.

Mission Readiness Testing (MRT), for Code 500, is done as a verification of all ground system requirements. These MRT tests, probably nine in number, may be run independently or in conjunction with spacecraft test opportunities. The MRM will also conduct interface checkouts to the Building 7/10 I&T area and to the launch site (TnSC) prior to any initial spacecraft testing.

It is expected that there will be two FOT test periods while the spacecraft is at the launch site. One while the Observatory is located in the Spacecraft Testing and Assembly (STA) facility (Launch - 3 months) and the second from the pad a few days prior to launch.